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Plasma surrounding the global heliosphere at large distances controlled by the solar cycle

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The past decade can be characterized by a series of key, groundbreaking remote energetic neutral atom (ENA) images (INCA, IBEX) and in-situ ion (Voyager 1 & 2) observations concerning the characteristics and interactions of the heliosphere with the Local Interstellar Medium (LISM). Voyagers 1 and 2 (V1, V2) discovered the reservoir of ions and electrons that constitute the heliosheath (HS) after crossing the termination shock (TS) 35deg north and 32deg south of the ecliptic plane at 94 and 84 astronomical units (1 AU= 1.5 x108 km), respectively. The in situ measurements by each Voyager were placed in a global context by remote sensing images using ENA obtained with the Ion and Neutral Camera (INCA) onboard Cassini orbiting Saturn. The ENA images contain a 5.2-55 keV hydrogen (H) ENA region (Belt) that loops through the celestial sphere and contributes to balancing the pressure of the interstellar magnetic field (ISMF). The success of any future mission with dedicated ENA detectors (e.g. the IMAP mission), highly depends on the antecedent understanding of the details of the plasma processes in the Heliosphere as revealed by remote sensing of the plasma environment characteristics. Therefore, we address here one of the remaining and most important questions: “Where do the 5-55 keV ENAs that INCA measures come from?”.
We analyzed INCA all-sky maps from 2003 to 2015 and compare the solar cycle (SC) variation of the ENAs in both the nose (upstream) and anti-nose (downstream) directions with the intensities of > 30 keV ions (source of ENA through charge exchange-CE with H) measured in-situ by V1 and V2, in overlapping energy bands ∼30-55 keV. ENA intensities decrease during the declining phase of SC23 by ∼x3 from 2003 to 2011 but recover through 2014 (SC24); similarly, V1 and V2 ion intensities also decrease and then recover through 2014. The similarity of time profiles of remotely sensed ENA and locally measured ions are consistent with (a) ENA originating in the HS, and (b) the global HS responding promptly (within ∼1-1.5 years) to outward-propagating solar wind changes throughout the SC. Further, recovery of the Belt during SC24 precedes asymmetrically from south to north in the general direction of the nose. This may be related to the non-symmetric evolution of solar coronal holes during SC recovery.